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Project evaluation with crowding out effects

H. Ike Van de Wetering
Iowa State University

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Abstract
Consider the technically feasible project (AX; AX^^; AX^) * Project output AX is achieved using a technology requiring the use of AX^ of input 1 and the quantity AX2 of input 2, If the project is scale neutral then we may write the technology of the project as (1; AX^^/^; ^2/^) where th latter ratios are input-output coefficients.-^ Both the scale and the input-output ratios are chosen autonomously but not arbitrarily. Typically the project output-input vector will reflect specific technological innovations such that it is not a subset of the currently known industry production function or technology set. The choice of project scale and s. ' * * technology reflects the (economic) rationality of the agency that proposes the project.

Disciplines
Economic History | Economic Theory | Taxation

ECONOMIC ISSUES IN DEVELOPMENT OF SUSTAINABLE ANIMAL HEALTH POLICIES[a]

by

James Kliebenstein
Arne Hallam

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Economic Issues In Development of Sustainable Animal Health Policies[a]

Animal health concerns are not new to agriculture. Animal health breakthroughs have been occurring with regularity. They represent an advancement in technology. Likewise, the need for evaluation of technologies is not new. While animal health represents an arena where some dramatic new discoveries are likely, approaches for their evaluation and effective implementation into American agriculture will likely include standard tools now available. This would involve tools such as budgeting, cash flow analysis, systems simulation analysis, and welfare analysis to measure benefits from improved animal health or disease control.

DISEASE CONTROL BENEFITS

Animal health or disease control benefits can be quite diversified and far ranging. They range from producers, to consumers, to agri-business, and government agencies. Producers gain from factors such as reduced animal mortality levels. Disease can also have an adverse impact on production efficiency. Factors such as feed efficiency, reproductive levels, rate of gain, labor efficiency, and treatment and medication costs are examples of production efficiencies impacted. Producers can also benefit from reduced use of disease control compounds. Probability of self inoculation etc. could be lessened. Disease control can reduce production variability leading to a more uniform product and more consistent marketing times. Producer harm from farm originated infections may also be lessened. Levels of animal or animal product condemnation too would be lessened.

Improved control of diseases which are livestock specific could lead to benefits to selected producers through consumer product substitutions. Demand may expand due to greater consumer confidence in the product from the improved perception of a more "wholesome" product.

Agri-businesses too can benefit from improved animal disease control. Meat packers and processors would have a more uniform product (raw material) of higher quality. They would need less time for sorting, handling, and disposing of damaged or condemned products. Health risks for meat inspectors, meat packers, and practitioners would be lessened. Demand for animal health consulting services too would likely increase as a necessary component for effective adoption of the health management strategies.

Reduction in animal disease would lead to an increased efficiency and reduction in the level of animal health regulatory function. Inspectors too would be subjected to a reduced exposure to zoonotic diseases.

Consumers benefit from improved animal disease control through cheaper prices for meat and animal products. Reduced animal disease would also lead to lower levels of compound use and reduced levels of drug resistance and residues in the food chain. Higher quality and more wholesome products would be available. Risks of sudden changes in product availability would be lessened through reduction in the level and occurrence of catastrophic disease. Benefits could also accrue from reduced probability of harm from farm-originated infections and disease.

CONSUMERS AND DISEASE CONTROL

Some of the benefits of disease control in production livestock were discussed in the previous section. Consumers clearly benefit from animals which are produced at lower costs with resulting lower market prices. The particular methods used to control disease in animals may, however, influence consumer satisfaction with the product and their overall consumption patterns. Consumers are concerned with at least the four following aspects of disease control and product quality: safety of the product as to natural disease characteristics (lack of bacterial infections, zoonotic disease etc.), safety of the product as to compounds added or techniques used during production or marketing (use of known carcinogens etc.), humane or inhumane treatment of animals during the production process, and the effects of the disease control methods used on the environment. Disease control methods developed through biotechnology may be of particular concern in relation to these control factors.

Improved control methods usually reduce the likelihood of natural disease problems and create a positive product image. Consumers are more likely to buy a product they perceive is free from disease or contamination. For example, consumers are more likely to buy poultry products they are certain are free from salmonella.

While disease control techniques improve product quality as far as organism levels, they may introduce compounds that create as much consumer concern as the original disease organisms. For example, meat preservatives may have the potential to be carcinogenic. Consumers may be concerned about the safety of meat from animals treated with growth hormones or food additives. They may be particularly wary of the safety of products developed through gene splicing techniques. Despite rigorous testing and careful procedures, consumers may still react negatively to products created using "new" techniques. Despite education programs, the idea of mutant horrors is still on the consumer mind. Some consumers may react negatively to transgenic animals due to moral or ethical beliefs. Even though researchers find no serious ethical issues in altering natural processes some consumers may be opposed to such techniques and not purchase products so produced.

Consumers may also be concerned about any physical discomforts caused to producing animals due to the use of implants, hormone treatments etc. While these factors are non-economic in character, they become economic because they affect the consumer's perception of quality or acceptability and therefore the price they are willing to pay.

Individual consumers may be concerned about the effects that disease control measures have on the environment. For example, consumers may be concerned about antibiotics in feed and the effects of residue levels in the environment. These residue levels may lead to problems of compound resistance etc. Whether such effects are actually significant or not does not change consumer reaction if consumers believe them to be important. Consumers may react to perceived environmental problems by boycotting products or attempting to alter regulations on the products use. While such external effects on any one consumer may be small, such effects may be large in aggregate so that even if consumers are not moved to act to control these problems, they are still a problem for the health of society as a whole. Socially optimal control measures must take into account these external effects and are discussed in the next section.

EXTERNALITIES IN DISEASE CONTROL

Externalities An externality is defined as an action by one individual that affects the level of well-being of another individual where the first individual does not take into account this effect in his decision-making. Externalities can be both positive and negative. For example, a person polluting a stream does not usually consider the effects on downstream individuals of the perceived inexpensive method of waste handling.

There are many examples of externalities in animal disease control. A farmer who eliminates pseudorabies from the swine herd reduces the probability that the neighboring swine or cattle herds may receive the virus. Packers allowing crushed bone in ground meats create a hazard for consumers. When a pork producer allows sulfa residues to be spread in the environment through improper feeding and handling procedures, he may create a health hazard either directly or through the cumulative effects of compound resistance. Such compound resistance will be discussed in a later section. When a cattle producer allows infectious waste to flow into the groundwater he is creating an externality for other users. When a farmer erodes the soil because the production effects won't be felt until far in the future he is imposing an externality on future generations.

With reference to disease control it is clear from the examples that externalities are of two types: externalities created by the spread of disease mechanisms and externalities created by the agents used to control disease. Society must deal with these off-site effects of disease control or non-control in determining optimal resource allocation.

Externalities and Sustainable Agriculture Sustainable agriculture is defined as the development and promotion of systems which promote responsible natural resource stewardship and long term farm profitability. Externalities are intimately related to natural resource use since many natural resources such as flowing water, air, and a disease free environment do not have clear property rights. Because property rights are not exclusive for many resources, externalities develop because producers do not consider the effects of their actions on these unseen property owners. Unseen owners in this context are the members of society at large and in future generations who will eventually reap the benefits or costs of current natural resource use. Sustainable systems are those that can remain profitable through time by the careful use and management of resources. When externalities are internalized in the decision making process, the resources of society are optimally used for everyone concerned. Externalities can be internalized in a variety of ways. The most common ways are through quantity and pricing regulations or changes in ownership patterns. An example of a quantity regulation is the banning of a particular chemical while a tax on use is a pricing method of control. Ownership can be changes through legal means such as giving a down stream firm the legal right to clean water.

Animal disease control measures can create externalities in several ways. Animal disease control in conjunction with sustainable agricultural systems can create additional externalities and problems of regulation. The reduced use of animal health products due to genetically improved animals may reduce some externalities due to chemical residues. Alternatively, the use of animal wastes as fertilizer in a sustainable system may increase dangers of groundwater contamination. The use of genetically engineered vaccines may help eliminate some diseases and thus improve the overall environment. Such vaccines may, however, discourage good management practices and increase the disease reservoir in the environment as animals do not show clinical signs but still carry the disease. Improved diagnostic tests may reduce the need for prophylactic treatment and the use of environment damaging chemicals but they may also encourage more treatment as the extent of the disease is apparent. Sustainable systems may also emphasize the control of disease through the proper handling and treatment of waste materials. There are no clear answers as to the effects of new disease control agents on the environment but sound research should consider the external as well as the internal effects in carrying out benefit-cost analyses for new and improved products.

COMPOUND RESISTANCE

One of the problems in the treatment of animal disease using chemical compounds is that organisms may become resistant to the compounds over time. Furthermore the use of a particular chemical may destroy beneficial and well as harmful organisms. The effects of chemical use on future immunity must be balanced against the benefits of current use. Biotechnology offers an opportunity to reduce compound resistance by reducing the need for chemical control through new and improved genetic material that may be disease resistant. Naturally immune animals may be more sustainable than those dependent on chemical control. Unfortunately, animals immune to one disease may be more susceptible to other diseases. Sustainability then means the use of compounds that do significantly reduce future profitability and environmental preservation.

BIOTECHNOLOGY AND ANIMAL DISEASE CONTROL ADOPTION ISSUES

The decision on adoption of animal disease control technologies will involve producer evaluation of a number of factors. Similarly, adoption and sharing of benefits will not likely be uniform across all producers. Nor will they necessarily be uniform by type and size of operation. Factors which will influence level of success in adoption will include such forces as management intensity, information availability, financing, production systems, and available resources.

Improved Management Effective and economic use of many animal health products will increase the need for improved production management. Some technologies will be complex requiring a clear understanding of animal biology and all the integrated production relationships. Information on disease population dynamics and epidemiology will be needed. Intense production management skills will be necessary to effectively integrate all factors. Health management strategies may mandate adjustments in production strategies. These in turn will likely improve production and/or cost efficiencies. These impacts need to be compared to the value of increased production keeping in mind demand and supply elasticities and resultant market effects.

Technological advancements, animal health included, will further increase the need for good records. These improvements will magnify the need for effective and intensive management. Managers will need records to aid in management decisions. Knowledge of production levels and changes in production levels as a result of animal health changes is needed. For this, baseline data are needed when evaluating cost effective animal health management decisions. Operations with subpar management may gain little from adoption of animal health management strategies. Those with top level management will be in position to make needed adjustments to effectively utilize the technologies.

Animal health strategies are not necessarily products that will make a below average manager an above average manager. To the contrary they may likely magnify and expand the differences. Management and production intensity needs to be present for effective and economic infusion into the operation before adoption of these innovations. The management capacity of below average managers will in particular need improvement for effective animal health product utilization. The premium for top level management will grow.

Relatively large and specialized farm operations have effectively streamlined the process of gathering information and management expertise. They are highly specialized. In comparison, a typical producer may have from two to six or even more enterprises. This is a situation where it is difficult to stay abreast of all the enterprises. Staying current on new animal health management and other interacting forces is a difficult task.

Programs aimed at development of and nurturing intensive management are needed. Management effectiveness will be a dominant variable in successful adoption. Development of effective interrelationships between public and private firms to enhance management is needed. Thought is needed on how this can be best accomplished. To be successful management intensity is needed before adoption of the new technological products.

Development of management strategies necessary for successful adoption of animal health strategies is also needed. As the competition for development of new and successful products continues, sight of management strategy development must not be lost. Successful adoption is needed if the product is viable economically. For this, producers need information on management strategies and systems necessary for use of the product. Development of this information may eliminate much trial and error in the adoption process.

Information An important issue is that of methods of and responsibility for distributing product information to producers. What are the interrelationships between the private and public sector? It seems that a combination of each is needed. However, this effective combination is open to much debate. The demand for consulting service activities will likely increase. Animal health products will increase the diversity and complexity of issues already facing farm operators. It will be very difficult for operators to remain current on all factors impacting all enterprises on the operation. Only the highly specialized and large operations will be able to internalize the information base. Others will need to effectively and efficiently incorporate some of this information base from outside sources.

Financial Some strategies may require that the financial position of the business along with available business management skills be in a good position.

Successful adoption will be much more likely for operations with these forces in place. Some products will introduce a level of instability into the industry over the adoption and adjustment process. Top level business management skills will be needed to effectively manage this instability. Moreover, effective use may necessitate a particular environment only accomplished through remodeling and investment in production facilities. Survival will be difficult for those in a weak financial position.

An important decision variable is that of production and income variability. Evaluation of the impact of the animal health product on production variability is needed. Some strategies will reduce variability while others will increase variability. Some which increase expected production levels may also increase production variability. Returns can be impacted similarly. Adoption will depend upon the risk aversion of the producer and her/his ability to absorb the potential increased risk levels. The new health management strategies may perform very well when all production factors perform as needed and in unison. However, if one of the factors is out of sync, production may be dramatically reduced. This further amplifies the increased pressure for intensive management as management can impact the degree of production (return) variability.

The upfront or fixed cost of animal health products and its effective adoption is an important consideration. Products which have high upfront costs for factors such as information and knowledge gathering, purchase fees, set up etc., can have impacts dependent upon farm size. There may be "lumpy" inputs. Large farms may be able to economically incorporate their use while it would be cost prohibitive for smaller operators. Smaller producers may need to rely on outside expertise and advise for effective incorporation of the product.

Resource Quality Animal health products may require an improved quality of resources to accompany their use. Products may be more effective in certain types of production systems. The production environment may be highly related to product effectiveness.

Specialized Product Some animal health products may lead to production of a specialized product. Examples may include drug or residue free products. The need for effective marketing to take advantage of any product premiums would be increased. This too may require product identification from producer to consumer. Open markets typically do not handle identification and separation of specialty products well. The need for marketing techniques such as production and/or marketing contracts may evolve for this type of product.

The availability of animal health strategies will not alter the success formula for farming. The key to success is and will be, first and foremost, good and effective management. For some products the importance of this success formula will be magnified. Without it probabilities of firm survival will be lessened. It should also be realized that animal health products can have an impact on farm size and effective operating level. Some are more size neutral than others. However few, if any, are completely size neutral. At a minimum there is time for information gathering etc. on the strategy that would not vary dramatically by farm size. Some may have a start-up or purchase fee for its use which is not volume related. Thus, larger operators will have an inherent advantage over smaller operators. None-the-less operations which are intensively managed will survive and will remain a sustainable part of the respective industries.

ANIMAL DISEASE IMMUNITY AND SUSTAINABLE AGRICULTURE

Sustainability has at least two parts: environmentally sustainable and economically sustainable. Improved animal disease immunity or resistance has tremendous potential on both fronts. It has the potential for improved profitability and enhancing the environment and creating a more sustainable agriculture.

Animal health is tied to animal genetics and the animals immune response to disease. It has been shown that the major histocompatibility complex (MHC) has an influence on the animals immune response and disease resistance (Dorf, 1981). For example, it has also been shown that economic traits of chickens such as liability, feed efficiency, egg production, fertilization rate, hatchability and growth rate are also associated with MHC (Bacon, 1987). Lamont points to reasons for selecting for genetic resistance to disease (Lamont, 1989). Genetic resistance can lead to reduced use of vaccinations and other products and associated costs. It leads to improved disease resistance and it offers increased protection as vaccinations lose effectiveness as a result of viral irritation. She concludes that potential exists for improving production efficiency and animal health through work with the MHC through both conventional breeding and genetic engineering.

These potential breakthroughs can provide large economic benefits across society. Livestock producers gain production efficiencies and reduced reoccurring health maintenance expenditures. The net impact is not known however. Products developed through genetic engineering will likely demand a premium price to obtain the genetics. The method of genetic availability and associated produce costs remain with a high degree of uncertainty. Reduced reliance on use of compounds for disease control can dramatically reduce the problem of viral mutation and the need for still other compounds. Development of the image of a "wholesome" product would be easier through national immunity. Consumers would benefit through lower levels of, or possibly even elimination of, restricted compounds showing up in the food chain.

It must be remembered that production traits can be positively or negatively associated with disease resistance. Govora and Spencer have indicated that it is feasible to improve disease resistance and selected production traits (Govora, 1983). However, disease resistance is typically disease specific. Information on positive and negative relationships are needed. The economics of a positive relationship are typically greater than negative relationships. However, this depends upon disease and the production trait with a negative relationship.

DISEASE CONTROL METHODS

Basic methods of disease control would include; medication, vaccination, eradication, and genetic resistance or natural immunity. In some situations medication, and/or vaccination may be low cost and highly effective. This may appear to be an easy and highly economic decision. For others, herd condemnation with mandatory slaughter may be felt to be quite effective and economic.

When evaluating disease control and/or prevention programs attention should be given to the programs impact on the breeding herd. What may appear to be very economic and highly effective may be a short run phenomena. Evaluation over the larger run may lead to different conclusions. For example, herd replacements tend to be selected from those lines which perform best under the disease management strategies in use. These may be animals which perform best under vaccination, medication, and eradication programs. This can reduce the expression of disease resistance (Govora, 1983). A population is selected that performs well under heavy disease control product use. But, it may also be a population that doesn't perform well if the products were to be withdrawn from the market.

Eradication programs have been successful for some diseases. However, these tend to be costly. One method of eradication is that of depopulation or whole herd slaughter. Economic studies have shown this may be costly. However, a major cost of this approach has been overlooked by all economic studies to date. That is the economic value of herd members which are naturally immune to the disease. These could be used to build a replacement herd for disease resistance. The long term economic value of these animals may be quite high. The old adage may apply "are we throwing the baby out with the bathwater?" Mandatory slaughter of breeding livestock may also be eradicating those animals which are immune while using multiplier animals which are not immune (Warner, 1987).

Screening animals for disease resistance may be an avenue for large economic and societal benefits. This would include such areas as genetic screening, serological tests, diagnostic tests.

CONTROL COST CASE STUDIES

National Animal Health Monitoring System Studies A National Animal Health Monitoring System (NAHMS) pilot study conducted at Ohio State University estimated annual dairy disease costs at $163 per cow. This included nearly $28 for drugs, biological and veterinary services (Miller, 1987). Lost milk production was estimated at $33 per cow. The University of Missouri farm business dairy results showed an average per cow cost of $40 in 1985 and $41 in 1986 for drugs and veterinary services. (Bennett, 1986, 1987). The Missouri data also pointed out wide fluctuations in these costs exist from farm to farm.

The percentage of herds and animals in the Iowa NAHMS pilot study which had positive titters for selected diseases is shown below in Table 1. While many of the herds had antibodies to several disease agents, little is known about what disease is costing producers in the form of reduced productive efficiency, death loss, etc.

The Iowa State NAHMS pilot study on swine estimated disease costs at $12,034 per farm (Owen, 1987). Annual per farm estimates ranged from $406 to $54,358. Such a large range reflects varying size of operations as well as varying effectiveness of management. Monthly costs per sow ranged from a low of $1.50 to a high of $41.80. Annual disease costs averaged $8.40 per head of slaughter animal. Primary losses occurred from pneumonia ($1.26), stillbirth ($0..87), salmonellosis ($0.47), diarrhea ($0.47) and hemophilus $0.33 (Owen, 1988). These losses represent observable losses and are likely an underestimate. Losses such as reduced weight gain, reduced litter size, etc., typically go unnoticed and are not considered. For some diseases these losses may be large.

The major disease cost item was that termed as "animal loss" or primary death loss. At $4.96 per head of slaughter animal it represented 59% of reported disease costs ($8.40 per head of slaughter animals). The major costs from animal disease are not disease prevention or treatment costs but losses from death, reduced animal production efficiency, etc. Therefore, greater efforts are needed in establishment of methods to measure reduced animal productivity. Variables currently receiving focus are overlooking some of these significant disease costs.

Pseudorabies Analysis Pseudorabies (Aujesky's disease) is a disease of swine with a long history in the United States. Beginning in the 1970's, pseudorabies began to be recognized as a major contributor to large losses in swine herds. Because of the increased severity of the disease there has been a strong effort to better understand the disease, develop improved methods of control, better vaccines and diagnostic tests, and analyze the benefits and costs of eradication versus herd by herd control without eradication. In 1984 a pilot project was begun in Marshall County, Iowa with the intent of eradicating the disease from the county. The project also investigated the costs of three alternative eradication procedures. By using data collected from positive herds, the costs of pseudorabies outbreaks was also measured. Some of the more interesting results are discussed here as examples of methods used in the economic analysis of disease control.

Using a pilot project data Hallam, Zimmerman and Beran evaluated PRV costs and associated cleanup costs. The cost per instance of a clinical sign are reported in Table 2. These losses were then multiplied by occurrence probabilities to determine the expected loss from a PRV outbreak. Occurrence probabilities also came from the sample data. These losses are reported in Table 3. They ranged from $20 to $40 per sow depending on assumptions used. They imply that the typical 100 sow herd would differ by sum of $2,000 to $4,000 from an outbreak.

The costs of eliminating pseudorabies from twenty three swine herds in Marshall County, Iowa were also estimated using Pilot Project data. Herds cleaning up used depopulation-repopulation methods, test and removal methods and a program of controlled vaccination with offspring segregation. The details of these plans are discussed in Zimmerman et. al. 1989. The results are summarized in Table 4. The most expensive plan was depopulation with a per sow in the herd cost of $204. The most economical plan was test and removal with a cost of $7.79. The most commonly used plan of offspring segregation had a per sow cost of $40.84. While test and removal was very inexpensive it is only appropriate when prevalence within the herd is very low. These rather large costs of the cleanup, when compared with the costs of an outbreak, imply that few infected herds will have an incentive to eliminate the disease from their herds unless they cannot vaccinate and have a high probability of future clinical signs. This is yet another example of the importance of externalities in animal disease control. The infected producer may rationally decide to live with PRV and not eliminate the disease since the costs of cleanup exceed the expected costs due to future outbreaks. However the producer does not consider the effects of this decision on the probability of his neighbor's herd contracting the virus. This implies that eradication efforts will need the cooperation and financial support of many producers and or the government.

A study of a large swine production operation in North Carolina estimated pseudorabies virus (PRV) losses at $16.21 per sow farrowed (Kliebenstein, et al, 1988). Losses ran for 17 weeks after the outbreak and amounted to 5.28% of pigs born during the outbreak period. This same study showed losses from "high loss" disease (primarily transmissible gastroenteritis) to be 14.04% of pigs born. The outbreak periods ran from one to four weeks. Respiratory diseases reduced production levels by approximately 9%. Length of this form of disease was quite variable. With the assumption of 7.8 pigs (U.S. average) per sow per litter, PRV cost per pig was $2.09 for that swine operation. The Iowa NAHMS study showed 7% of the hogs had positive titters for PRV (Owen, 1987). Extrapolating to a national scale, if 7% of the 80 million market hogs produced annually are infected with PRV, it means 5.6 million are infected. If this is true and if losses associated with PRV were to be reduced by half, the cost saving would be approximately $5.9 million annually (5.6/2 x $2.09).

Using data from the Iowa Pilot Project and other surveys a benefit cost analysis of a national eradication program was completed (Hallam et. al. 1987). The analysis considered the costs and benefits of a ten year eradication plan.

States were assumed to follow different protocols depending on disease severity. The benefits of eradication included eliminated clinical disease and vaccination and reduced testing costs. Non-clinical disease costs were not included since data was not available or of questionable quality. The discounted value of these benefits was determined to be $136.4 million using a 10% discount rate and $271.5 million using a 6% discount rate. The total costs of the program to producers and government were $134.4 million using a 10% rate and $155.8 million using a 6% rate. The benefit cost ratio was not large but the program has been undertaken.

Swine Slaughter Check and Panel A Missouri swine panel study showed direct swine health expenditures ranging from $0.59 to $2.59 per pig (Kliebenstein, et al, 1983). Total confinement and mixed housing systems tended to have higher per-pig expenses. The two leading expense items were for pneumonia and atrophic rhinitis prevention and control. This range in health expenditure cost is consistent but narrower than that shown in the Iowa State NAHMS report. The Missouri study showed that the primary disease seasons were the fall and winter quarters. During the winter quarter, 48% of the hogs were reported to have some form of health problem. This was 40% during the fall and 31.5% for the year.

A slaughter check study showed the two primary morbidity events in swine were pneumonia and atrophic rhinitis (AR) (Boessen et al, 1988). Losses from pneumonia for a "batch" producer averaged $1.09 per hog. For a continuous producer, losses averaged 1.5 cents per hog per day or $5.48 per hog production space per year. Losses from AR were $0.95 per hog in a "batch" production system. It was 1.3 cents per hog per day or $4.75 per hog production space per year in a continuous production system.

A study on TGE calculated losses at $1.49 per hog in infected herds (Miller and Kliebenstein, 1985). It was $0.18 per hog when averaged over all herds. A program that reduced TGE losses from $0.18 to $0.09 per head would reduce production costs by $7.2 million annually.

Johne's Analysis A study of Johne's (Paratuberculosis) disease in a dairy herd shows that method of control can have a dramatic impact on number of cows infected (Walker). This is shown in Table 5. The model developed was an epidemiologic-economic simulation of a dairy herd over 30 years. Johne's disease and selected control alternatives were incorporated into a dynamic interactive approach. The initial herd level prevalence rate when first diagnosed had an impact on effective control alternatives. Vaccination or fecal culture testing were effective control devices when the initial prevalence rate was low. Alternatively, when the prevalence rate was high (12 percent or higher) both fecal culture testing and vaccination were needed to gain quick disease control.

Johnes disease costs increase as disease level increases. At low prevalence levels the impact is minor. For a 6 percent initial prevalence rate, if specific disease control practices were not implemented, the decline in discounted (10%) returns to labor and management was less than $40 per year. This was for an 80 cow herd. Labor and management returns fell by about $1,800 per year for an initial prevalence rate of 12 percent. This compared to a $4,000 per year decline at the 28 percent initial prevalence.

Johne's disease can have an interactive effect on long run herd milk production. If disease is not present or at lower levels, cull rates are lower and cows have a greater chance of remaining within the herd until after they reach peak production and lactation production potential begins to decline. During this time heifer sales may increase if heifer replacements are not needed in the milking herd. This points out the importance of using the heifer pool wisely and economically. It should be noted that this interactive effect is generally limited to low disease prevalence rates such as 6 percent. For higher prevalence rates, the increased number of infected cows prohibits producers from being as selective in choosing which replacement heifers to bring into the herd. All replacement heifers may be needed and a younger lower producing herd results.

Losses increase as level of control effectiveness decline. This is shown in Table 6. While this should not be too revealing, there are some interesting relationships in Table 6. If there is a control that is highly effective and cost efficient the need to start an early control program is lowered. For example, with a control program that is 90 percent effective the discounted returns are the same with an initial prevalence rate of 6 or 12 percent. For diseases which have low efficiency of control the need for information on disease prevalence is heightened. Discounted return decline dramatically. This points to the need for improved disease diagnosis. It offers the benefit quicker action against disease. Additionally, it can reduce risks from disease and enhance the potential for disease control strategies rather than the disease prevention approach.

SUMMARY

Biotechnology offers much for development of a more sustainable agriculture. Benefits of an effective and sustainable technology are quite diverse and far ranging. They range from producers to consumers, agribusiness firms and government agencies. It must also be recognized that some products have both benefits and costs associated with their use. Some may reduce problems while increasing another. Thus, wise and prudent use is needed in both development and use of biotechnologiec products.

As with many new technologies there are no clear answers on the products impacts on the environment and society. None-the-less, potential impacts need to be analyzed to determine likely scenarios. The potential for catestrophic outcomes needs to be realized with an assessment of the need for society to bear risks that may provide low benefits properly evaluated. Socially optimal disease control measures must take into account all costs and benefits - the direct as well as indirect or external.

Decisions on producer adoption of animal disease control techniques will involve a number of factors. These include management intensity, information availability, financing, production systems, and available resources. These factors are not uniform across producers and thus sharing of benefits and costs will not likely be uniform. Animal disease control strategies are not necessarily products that will transform below average managers into above average managers.

For effective and efficient adoption of these biotechnologies programer aimed at development and nurturing intensive management are needed. Identification of management strategies which accompany the products are needed.

A sample of cost analysis of selected diseases shows that economic analysis of animal disease control alternatives is an important component of disease control policies. These costs need to be evaluated at the producer as well as societal level.

Table 1. Percentage of Herds and Animals with Positive Titters for Disease - NAHMS

Positive	% of Herds Animal Positive	% of Total Disease
Transmissible gastroenteritis	52	24
Mycoplasma hyopneumonia	70	43
Hemophilus pleuroneumoniae	89	47
Pseudorabies	15	7
Porcine parvovirus	92	68
Swine influenza	70	43
Eperythrozoenosia	19	3
Swine dysentery	85	27

Table 2. Valuation of losses due to clinical PR.

Type of loss	Cost
Term abortion	$348.66
Abortion at 3 months	340.14
Stillborn or mummified pig	37.20
Death of a baby pig	47.63
Death of growers/finishers	56.90
Open at 60 days (sow sold)	308.97
Open at 60 days (sow rebred)	103.98
Open at 30 days (sow sold)	231.50
Open at 30 days (sow rebred)	39.16

Table 4. Cleanup costs by method[a]

	Depopulation-Repopulation			
	Feeder pig finishers (n=3)	Farrow to finish (n=1)	Test and removal (n=5)	Controlled vaccination w/ offspring segregation (n=14)
Veterinary Services[b]	$ 0.01	$ 0.88	$ 0.54	$ 0.74
Vaccination				
Vaccine[b]	0.00	46.88	1.75	7.20
Labor	0.00	7.50	0.32	0.56
PRV Surveillance				
Testing and tagging[b]	0.08	9.97	4.51	4.15
Labor	0.01	0.95	0.67	0.38
Cleaning and Disinfecting	0.01	10.70	0.00	0.96
Isolation and Segregation				
Facilities	0.23	8.73	0.00	0.00
Labor	0.05	7.50	0.00	0.23
Transportation	0.00	3.95	0.00	0.00
Downtime	0.00	106.60	0.00	0.00
Losses at sales of culled breeders	0.00	0.00	0.00	26.62
Total producer costs	0.30	145.93	0.99	28.75
Total program costs	0.09	57.73	6.80	12.09
Total costs	0.39	203.66	7.79	40.84

[a]Costs are stated on a per hog marketed basis for feeder pig finishers and per sow basis for all others.
[b]Denotes costs borne by the Iowa Pilot Project.

Table 3. Rate of losses per sow and costs due to clinical PR.

	Rate of loss per sow	Cost per sow (non-seedstock) Non-replacement	Replacement	Cost per sow (seedstock)	
Abortion	0.030	$10.33	$ 6.22	$ 36.77	
Stillbirths/mummies	0.155	5.77	3.45	18.65	
Death of a baby pig	0.361	17.19	9.75	49.81	
Death of growers/finishers		0.004	0.26	0.15	0.66
Open at 60 days (sow sold)		0.008	2.47	1.38	9.52
Open at 60 days (sow rebred)		0.008	0.83	0.80	1.04
Open at 30 days (sow sold)		0.015	3.47	1.47	16.68
Open at 30 days (sow rebred)		0.015	0.59	0.57	0.72
Reduced rate of gain in survivors		0.044	0.29	0.00	0.29
Total per sow (case if sow sold)			39.78	22.42	132.38
Total per sow (case if sow rebred)			35.26	20.94	107.94

Table 5. Number of Cows Infected with Johnes for Selected Control Strategies

Initial Prevalence Rate	Level of Vaccine Effectiveness		
	90	50	10
	VACCINATION		
6	15	15	127
12	33	70	259
20	57	110	289
	VACCINATION AND FECAL CULTURE TEST		
6	12	17	31
12	13	19	44
20	13	19	53

Table 6. Discounted Returns for Vaccination Strategy By Prevalence Rate and Vaccination Effectiveness Level (1)

Initial Prevalence Rate	Level of Vaccine Effectiveness		
	90	50	10
6	$379,272	$371,273	$368,278
12	$379,272	$350,484	$347,470
20	$360,559	$334,191	$331,703

(1) Discount rate is 10 percent.

REFERENCES

Bacon, L.D. "Influence of MHC on Disease Resistance and Productivity, Poultry Science, 66:802, 1987.

Bennett, M. 1986 Dairy Enterprise Business Earnings and Costs. Farm Management Newsletter FM87-5, Missouri Cooperative Extension Service, 1987.

Bennett, M. 1985 Dairy Enterprise Business Earnings and Costs. Farm Management Newsletter FM 86-3, Missouri Cooperative Extension Service, 1986.

Boessen, C., J.B. Kliebenstein, R. Cowert, K. Moore and C. Burbee. Effective Use of Slaughter Checks to Determine Economic Losses from Morbidity in Swine. Proceedings of the 5th International Symposium of Veterinary Epidemiology and Economics, Copenhagen, Denmark, 1988.

Curtis, Stanley E., "Management and Environmental Considerations for Successful Use of Repartitioning Agents," Pork Industry Conference, College of Agriculture, University of Illinois at Urbana-Champaign, 1987. Economics of Animal Health.

Dorf, M.E. ed. "The Role of the Major Historanpatibility Complex in Immunobiology," Harland Press, New York, NY, 1981.

Govora, J.S., and J. L. Spencer. "Breeding for Immune Responsiveness and Disease Resistance," Animal Blood Groups and Biochemical Genetics 14, 1983.

Hallam, A., J.J. Zimmerman and G.W. Beran, "A Benefit Cost Analysis of the Proposed National Pseudorabies Eradication Program: Summary Report" in Proceedings of the United States Animal Health Association Ninety First Annual Meeting, Salt Lake City, Utah, 1987

Hallam, A., J.J. Zimmerman and G.W. Beran, "The Cost of Clinical Pseudorabies in Iowa Swine Herds", Iowa State University, Agriculture and Home Economics Experiment Station Cooperative Extension Service, AS-590, December 1987

Hayenga, Marvin, Brian Buhr, James Kliebenstein and Arne Hallam. "Socioeconomic Considerations: Transgenic Animal Research," Proceedings of the Transgenic Animal Research Workshop, Technology and Social Change Series No. 10, Iowa State University Research Foundation, 1989.

Kliebenstein, J.B., D. Patterson, K. Moore and D.G. Thawley. Economic losses from pseudorabies in a swine farrowing operation. North Central J. of Agr. Econ., 1988.

Kliebenstein, J.B., C.L. Kirtley, and L.A. Selby. A survey of swine production health problems and health maintenance expenditures. Prev. Vet. Med., Vol. 1, 1983.

Lamont, S.J. "The Chicken Major Histocompatibility Complex in Disease Resistance and Poultry Breeding," Journal of Dairy Science, Vol. 72, No. 4, 1989.

Miller, G.Y. Evaluation of Economics and Epidemiologic Data from the National Animal Disease Detection System (NADDS). Ohio State University Research Foundation, Ohio State University, October 1987.

Miller, G.Y. and J.B. Kliebenstein. The Economic Impact of Clinical Transmissible Gastroenteritis for Swine Producers Participating in the Missouri-Mail-in-Record Program. Prev. Vet. Med., Vol. 3, 1985.

Owen, W. J. Initial Analysis of a Valid Food Animal Disease Database for Iowa. Iowa State Journal of Research, Vol. 62, No. 2, November 1987.

Owen, W.J. Unpublished data, Iowa State University School of Veterinary Medicine, 1988.

Walker, Kevin D. "Economic Analysis of the Effects of Paratuberculosis (Johnes Disease) In Dairy Herds," unpublished Ph.D. dissertation, University of Missouri, 1985.

Warner, C.M., D.L. Meeker, and M.F. Rothschild. "Genetic Control of Immune Responsiveness: A Review of It's Use as a Tool for Selection for Disease Resistance," Journal of Animal Science, Vol. 64, 1987.

Zimmerman, J.J., A. Hallam and G.W. Beran, "The Cost of Eliminating Pseudorabies from Swine Herds in Iowa", Preventive Veterinary Medicine, (forthcoming 1989)